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DESIGN AND FABRICATION OF TRANSPORT SPHERES FOR  
HIGH VACUUM USE

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## Design and Fabrication of Transport Spheres for High Vacuum Use

### 1.0 INTRODUCTION

During this period, Wentworth Institute of Technology supported the efforts of the Whole Air Sample Lab of the Composition Branch, AFGL, in the design and fabrication of components, assemblies and related equipment used in the study of atmospheric composition. This included conducting the necessary engineering liaison with AFGL for the purpose of establishing design parameters of instruments; designing, in mechanical detail, components and assemblies; fabricating items resulting from this design; determining the needs for possible re-design, and making recommendations for further modifications.

### 2.0 REQUIREMENTS

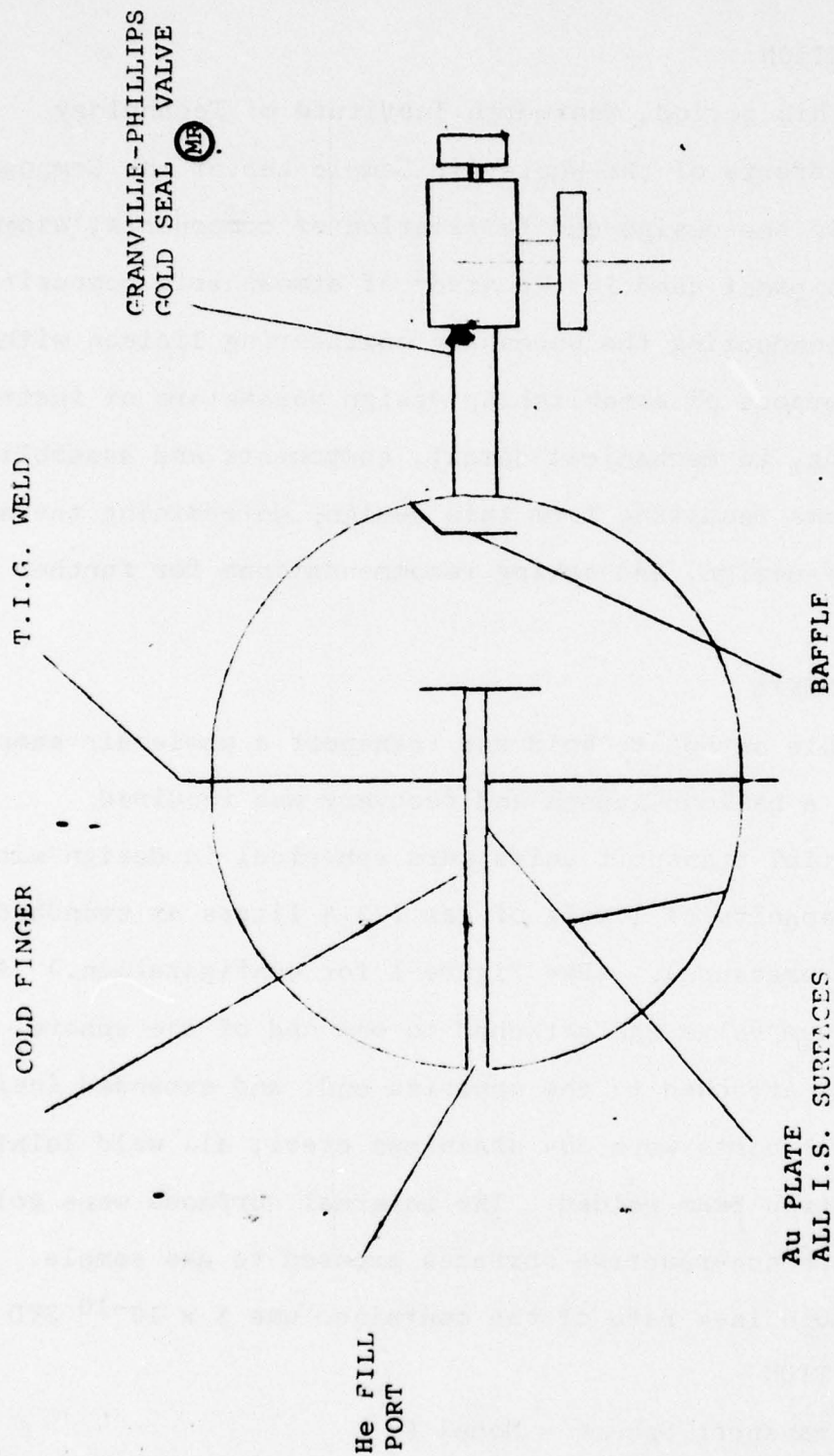
A reliable method to hold and transport a whole air sample gathered after a balloon launch and recovery was required.

The initial transport units were spherical in design with a volumetric capacity of 1 mole of gas (22.4 liters at standard atmosphere and pressure). (See Figure 1 for configuration.) An ultra-high vacuum valve was attached to one end of the sphere. A cold finger was attached to the opposite end; and extended inside the sphere. All parts were 304 stainless steel; all weld joints were T.I.G. or Electron Beam welded. The internal surfaces were gold-plated to insure non-reactive surfaces exposed to gas sample. The maximum allowable leak rate of the container was  $5 \times 10^{-10}$  STD cc/sec.

### 3.0 DESCRIPTION

#### 3.1 Gas Transport Sphere - Model I

The hemispheres were generated by spin forming and required a pickling process to remove the surface scale. After the required



MOD I  
GAS TRANSPORT SPHERE  
Fig. 1

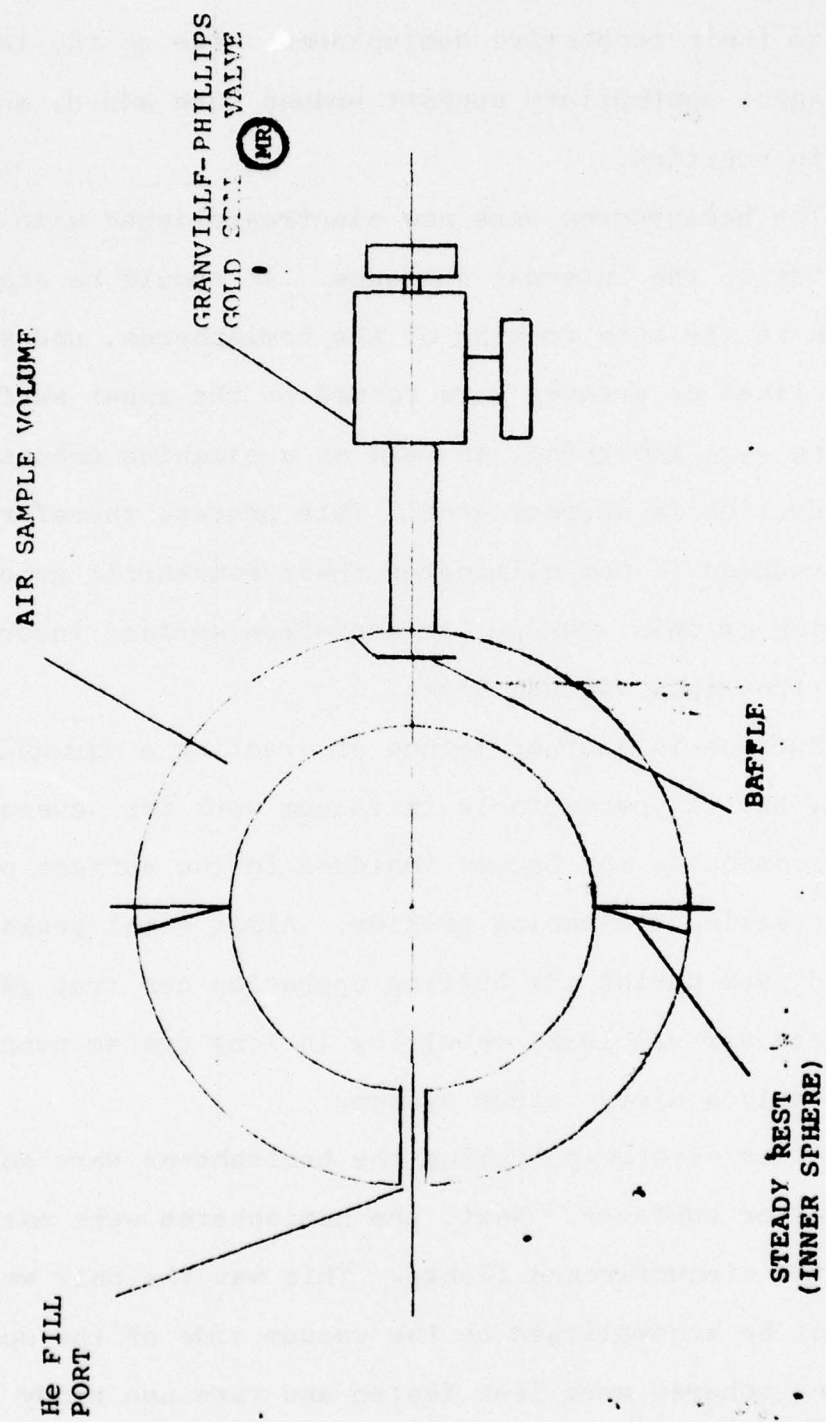


machining of the hemispheres, the cold finger and valve were T.I.G. welded to their respective hemispheres. Due to the length of the cold finger, appropriate support braces were added, and T.I.G. welded in position.

The hemispheres were now electro-polished with particular care given to the internal surfaces. It should be stated here that due to the spin forming of the hemispheres, undesirable concentric lines or grooves were formed on the inner surfaces. Electro-polishing -- a smoothing, as well as a cleaning process -- leads to a reduction in surface area. This process therefore, significantly reduced if not eliminated these concentric grooves. The generation of this smooth, scratch-free surface insures a clean surface free from virtual leaks.

Buffing is another method of creating a smooth, scratch-free surface, but is unacceptable in vacuum work for several reasons. Buffing compounds may become imbedded in the surface pores of the metal, creating a cleaning problem. Also, metal peaks bent and smoothed over during the buffing operation can trap gas particles, and create virtual leaks resulting in long system pump down and consequently a dirty vacuum system.

After electro-polishing, the hemispheres were gold-plated on the interior surfaces. Next, the hemispheres were mated and welded around the circumference flange. This was the only weld which could not be accomplished on the vacuum side of the spheres. The completed spheres were leak tested and were now ready for lab tests prior to flight. Figure 1 describes the general configuration of these transport spheres.



MOD II  
GAS TRANSPORT SPHERE  
Fig. 2



### 3.2 Gas Transport Sphere - Model II

Prior to the next balloon flight, new transport spheres were designed and fabricated incorporating one modification. The cold finger was no longer a tube extending into the sphere, but an internal sphere with an external volume of 11 liters. This, of course, reduced the gas handle volume to slightly more than a half mole, or 12.4 liters. These new parameters were still within acceptable limits for effective sample gathering.

The external configuration remained the same as Mod I, but the inner sphere was fabricated from hydro-formed hemispheres. This method of forming left the inner and outer surfaces of the hemispheres in excellent condition. The hemispheres were electro-polished with particular attention given to surfaces exposed to the vacuum side (gas contact).

To restrict movement, the inner sphere was supported at four points around its circumference between inner and outer spheres. The outer hemispheres were welded around the circumference, and leak tested.

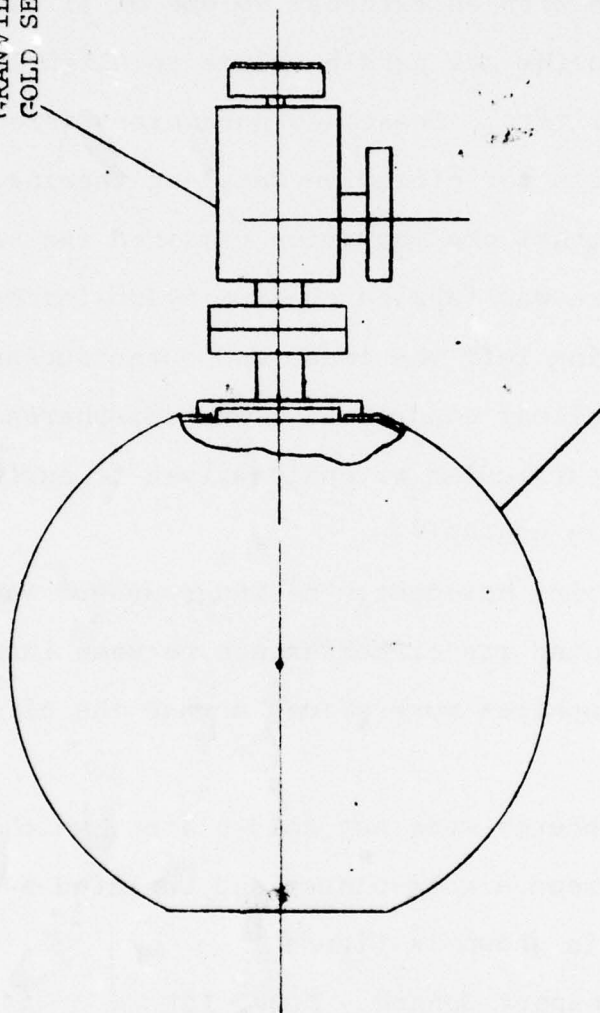
These spheres were not gold-plated, which allowed the comparison between a gold-plated and unplated surface. The Mod II configuration is shown in Figure 2.

### 3.3 Gas Transport Sphere - Model III

Due to a change in the gas handling mode, a new transport sphere design was initiated. The design was simplified by the elimination of the cold finger. The design incorporated the use of mixing bowls as hemispheres, as a means of reducing the cost of spin forming or hydro-forming hemispheres.

GRANVILLE-PHILLIPS  
GOLD SEAL VALVE

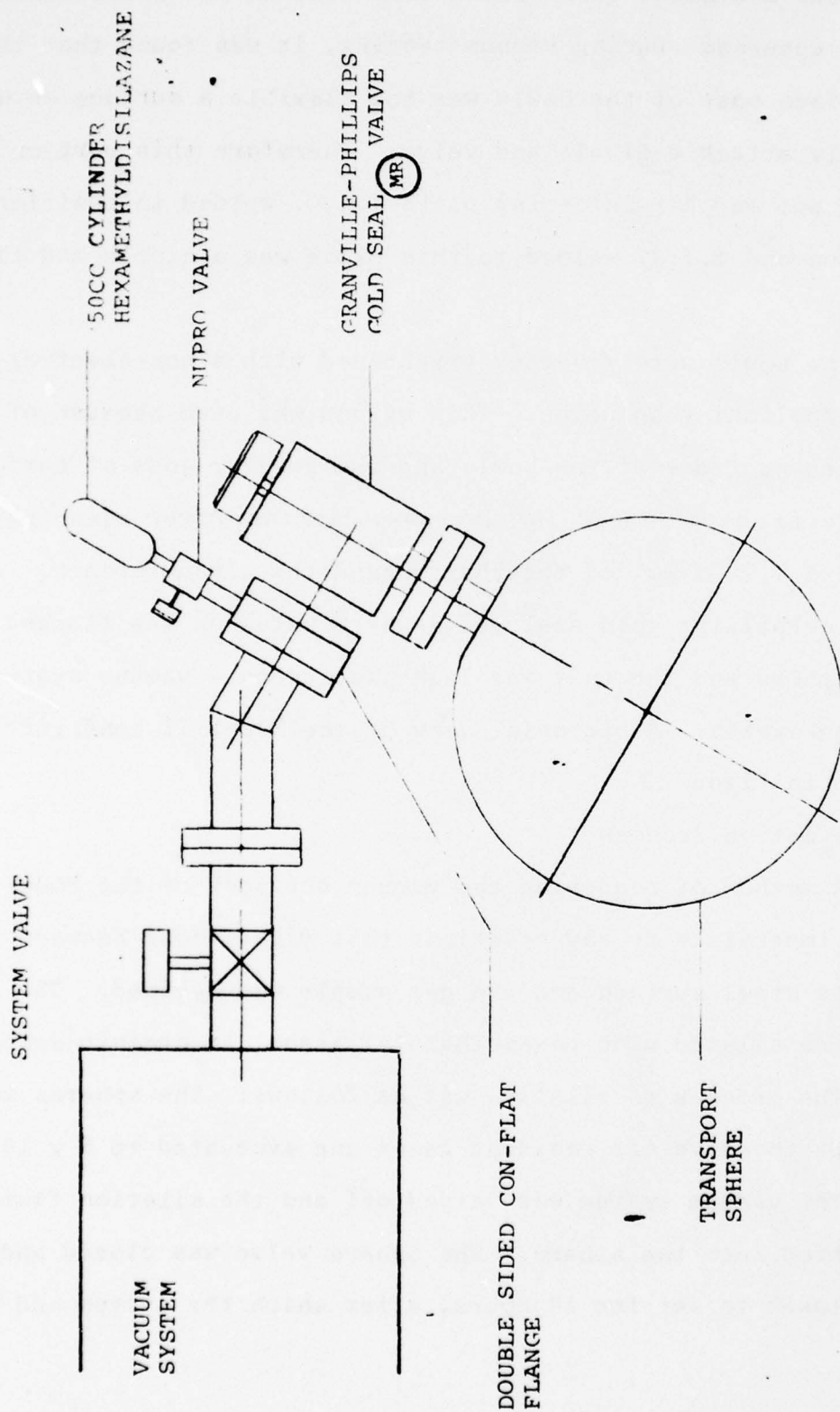
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TRANSPORT  
SPHERE

MOD III  
GAS TRANSPORT SPHERE  
FIG. 3





SILATION PROCESS

Fig. 4

Four and eight quart bowls were used in the fabrication of these spheres. During vacuum testing, it was found that the flat surface base of the bowls was too flexible a surface on which to rigidly attach a nipple and valve. Therefore this portion was machined out and a reinforcing plate T.I.G. welded in position. Mounted on and T.I.G. welded to this plate was a nipple and flange assembly.

The bowls were diversey brightened with a non-electrolytic cleaning/polishing solution. This method was used because of the thin cross-sections of the bowls and the greater loss of surface area material experienced in electro-polishing. After cleaning, the bowls were T.I.G. welded together around the circumference. A Granville-Phillips gold seal valve was mounted on the flanged end of the sphere and the unit was leak checked on a vacuum system for vacuum integrity. A pictorial view of the Model II configuration is shown in Figure 3.

#### 3.4 Silation Process

A method of rendering the vacuum surfaces of the Model III spheres impervious to any reactions that might occur between the stainless steel surface and the gas sample was devised. The surfaces were siliated with hexamethyldisilazane, an organic compound.

The process of silation was as follows: The spheres were baked out to drive off residual gases and evacuated to  $5 \times 10^{-5}$  torr. The vacuum system was valved off and the silation fluid slowly admitted into the sphere. The sphere valve was closed and the unit allowed to set for 24 hours, after which the system and sphere

valves were reopened and the unit pumped down to  $5 \times 10^{-8}$  torr.

The valves were closed and the unit removed from the system.

The transport spheres were ready for lab test prior to flight. A pictorial view of this process is shown in Figure 4.

#### 4.0 CONCLUSION

In the first two transport spheres, i.e. Models I and II, a liquid helium cold finger was required and both spin forming and hydro-forming were utilized in their construction. The Model III transport sphere required no cold finger due to the introduction of a cryogenic tri-sampler; and it was constructed from stainless steel salad bowls. With some reinforcement of these bowls, i.e. the addition of a plate on the bottom of the bowl supporting the valve, they have proved satisfactory and the cost savings over the previous designs were considerable. The process of diversy cleaning and silation of the vacuum surfaces seems to be a reliable method of rendering stainless steel surfaces non-reactive to the air samples. This method has a definite cost saving over gold plating, in addition to increased reliability.



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